DOCUMENT-IDENTIFIER: US 5368591 A
TITLE: Heated balloon catheters

ABPL:
Device and method for heating tissue, the device having a catheter shaft for insertion into a patient's body, a chamber formed by a collapsible balloon mounted on the catheter shaft and filled with an electrically conductive fluid, two or more electrical contacts enclosed within the chamber, a power supply for applying an electrical potential to the contacts, and a two or more conductors for connecting each of the contacts to the power supply. The fluid is heated on the basis of I.sup.2 R losses by a radio frequency electric current flowing between the electrodes, and the fluid in turn heats the surrounding tissue by heat transfer through the wall of the chamber. According to the method, the apparatus is inserted into the patient's body, the chamber is filled with an electrically conductive fluid, and an electrical potential is applied to the contacts. The apparatus functions as a temperature source. A thermister sensor in the balloon or in contact with tissue responds to the heating effect to control the application of the current. Advantageously, by periodic sensing of temperature, and application of controlled rf power, a preset constant temperature is maintained at the selected sensing point, either at the internal body site or the liquid within the balloon. In this way carefully controlled therapy can be conducted at constant temperature.

DEPR:
Referring to FIG. 5, another embodiment of the invention is shown in which temperature sensor 26 is placed in direct contact with tissue 44, outside of balloon catheter 34. Wires 60 and 62 connect temperature sensor 26 with

temperature control circuit 52, and wires 20 and 18 connect electrodes 22 and
24 respectively with RF power supply 50. Temperature control circuit 52
regulates RF power supply 50 in response to the input from temperature sensor
26.

DEPR:
Referring to FIG. 6, another embodiment of the invention is shown in which the
temperature sensor consists of a pressure transducer 64 in conjunction with
pressure sensing circuit 66 and pressure-to-temperature conversion circuit 68.
In this embodiment, the electrodes 22 and 24 are small enough that the electric
current density in the immediate vicinity of the electrodes can induce
localized boiling, which aids in the convection of heat from the electrodes to
the surrounding tissue 44. The balloon material is heat-set at a temperature
in excess of 100.degree. Celsius, so that the balloon material remains
dimensionally stable when the fluid 36 within the balloon 8 boils at about
100.degree. Celsius. A flexible tube 70 provides a conduit for fluid into
lumen 14 of catheter shaft 10. Inflator 72 is used to inject fluid into
flexible tube 70 until a desired pressure is obtained, as indicated by pressure
gauge 74. When RF power supply 50 is activated, the high electric field
density in the immediate vicinity of each of the electrodes 22, 24 can induce
localized boiling of fluid 36. As the fluid 36 heats up, the boiling increases
in intensity. The boiling causes the pressure inside balloon 8 to increase.
The increase in pressure is measured by pressure transducer 64, as an indirect
indication of the amount of heating of the fluid 36, according to phase change
pressure/temperature relationships. Temperature control circuit 52 regulates
RF power supply 50 in response to the input obtained from
pressure-to-temperature conversion circuit 68. Temperature display circuit 76

displays the temperature obtained from pressure-to-temperature conversion
circuit 68. Impedance stability sensor 78 detects the initiation of boiling by
sensing the instability of catheter impedance due to the formation of vapor at
the surfaces of electrodes 22 and 24.

DEPR:
Referring to FIG. 1, balloon catheter 34 may be used as a heat source during or
after angioplasty to seal the splitting of the intimal layers of the wall of
blood vessel 42 that occurs during angioplasty, and to mold the vessel wall.
The blood vessel may be a coronary artery, or a peripheral artery such as an
iliac, femoral, renal, carotid, or popliteal artery. The user first preselects
the desired therapeutic temperature (temperature set voltage 92, FIG. 7), and
sets the length of time for which balloon 8 is to be heated (time set switches
112, FIG. 6). A percutaneous insertion is made with a needle, and guide wire
46 is introduced into the blood vessel 42. Balloon catheter 34 follows the
wire. If balloon 8 contains conductive radiopaque fluid, the location of
balloon 8 can be monitored by means of fluoroscopy. Balloon 8 is inflated
through lumen 14 with either saline, a conductive radiopaque fluid, or a
mixture of saline and a radiopaque fluid, to a pressure of 4 to 17 atmospheres,
in order to expand the wall of blood vessel 42. The balloon remains inflated
for about 20 seconds or longer, depending on the particular blood vessel upon
which the angioplasty is being performed. Either during or after the plastic
deformation of the vessel wall, with balloon 8 inflated to at least a low level
of pressure, the user depresses footswitch 122 (FIG. 7) to initiate the
bi-polar heating between the electrodes 36. Heat is dissipated into the fluid
according to the formula P=I.sup.2 R where P is the power that is dissipated
into the fluid, I is the current that is passed through the

electrodes, and R
is the resistance of the fluid. The heat from the fluid is conducted across
the balloon wall into the surrounding tissue 44. For angioplasty procedures,
RF power supply 50 supplies a maximum current of 1/4 amp, and the power
dissipated into fluid 36 is about 10 to 25 watts. The fluid will heat to the
temperature set by the user, which may be in the range of 45.degree. Celsius
to 80.degree. Celsius. Heating will continue until the time set by the user
has elapsed, or until the user deactivates footswitch 122.

DOCUMENT-IDENTIFIER: US 6283989 B1
TITLE: Method of treating a bronchial tube with a bronchial stenter having
diametrically adjustable electrodes

DEPR:
FIGS. 1A and 1B show that electrodes 102 and 104 are connected via cables 122
and 142, respectively, to a radio frequency (RF) generator 130 with controls
138. Rod 110 is also connected to syringe 150 which is employed to inject a
fluid from source 146 through valve 148 into the balloon.

DEPR:
The amount of inflation of the balloon is determined by the operating surgeon
who monitors the balloon expansion by means of endoscopy or by other suitable
imaging methods of the art. Generally, the heat required is induced in the
tissue of the bronchial tube wall by the RF or microwave radiation emitting
from the electrodes. The RF or microwave energy would be applied while
observing for changes via simultaneous endoscopy, or other suitable imaging
methods of the art.

DEPR:
Alternatively, heat treatment apparatuses employing a unipolar electrode can
also be employed. For instance, in the case of the embodiment shown in FIGS.
1A and 1B, the heating device can have one or more inner electrodes 102 and/or
104 on the balloon surface and an outer or external electrode 188 that has a
much larger surface area than that of the internal electrode(s) and that is
placed on the outer surface of the patient's body. For example, the external
electrode can be an external metal mesh or solid plate that is placed on the
skin. Both the internal and external electrodes are connected to an RF
generator which produces an electric field at a high frequency

within the balloon. Because the collective surface area of the internal electrode(s) is much smaller than that of the outer electrode, the density of the high frequency electric field is much higher around the internal electrode(s). The electric field reaches its highest density in the region near the internal electrode(s). The increased density of the field around the internal electrode(s) produces localized heating of the tissue.

DEPR:
As is apparent, the heat treatment device of the present invention can comprise more than one electrode that is positioned at or near the distal end of the elongated rod. For example, FIG. 7 depicts schematically the distal end 700 of a heat treatment device which comprises electrodes 701, 702, and 703. In this configuration if the device operates in the bipolar mode, two of the three electrodes (e.g., 701 and 702) are connected to one pole of the RF generator and the other electrode (702) is connected to the other pole. Heat will be generated in the tissue adjacent the region between electrodes 701 and 702 and the region between electrodes 702 and 703. These electrodes 701, 702, and 703 can be attached to the exterior surface of a balloon, alternatively they represent adjustable coils in embodiments that do not require a balloon.

DOCUMENT-IDENTIFIER: US 6251109 B1
TITLE: Process and device for the treatment of atrial arrhythmia

BSPR:
The present invention is an ablation catheter useful for ablation procedures within a vessel of a human, or on the os of that vessel, particularly a pulmonary vein. A first and a second balloon are secured to the catheter, with the second balloon secured to the catheter and located inside the first balloon. The balloons, when inflated, seal the vessel and prevent substantially the flow of blood through the vessel around these balloons. An introduction system is also included as an element of the ablation catheter to introduce a conductive media to the space within the first and second balloons when inflated. The first balloon contains a plurality of balloon openings in its outside surface through which the conductive media is expelled to contact the tissue of the vessel. An ablating system is also included as an element of the ablation catheter, which system is secured to the catheter at a location within the first, outer balloon, but outside of the second, inner balloon. The ablating system includes one or more Rf energy ablation electrodes, which may be in the form of a coil electrode or a ring electrode. The conductive media conducts the ablating energy from the ablating system out through the balloon openings in that first balloon to contact the tissue located in the vessel, or on the Os of the vessel, adjacent to the balloon openings to form a circumferential ablation lesion in the vessel or on the os of the vessel.

DEPR:
The ablating system, preferably a pair of Rf coil electrodes (30), or ring electrodes (130), which are secured to the outer surface (13) of

the catheter (12) at a location within the outer balloon (20) and outside of the inflated inner balloon (22), then emit energy which is conducted by the conductive media through the balloon openings (28) in the surface (34) of the outer balloon (20) to the surface of the tissue in the pulmonary vein (14). Sufficient energy is emitted to create a circumferential lesion of sufficient width and depth to block completely the passage of the atrial premature contractions through the pulmonary vein (14). The temperature of the tissue of the pulmonary vein (14) may be monitored by temperature sensors, such as thermistors or thermocouples (not shown), located on the surface (13) of the catheter (12) outside the balloons (20, 22). In addition, sensing electrodes (not shown) may be located proximal from the balloons (20, 22) to sense electrical activity through the vessel after the ablation procedure has been completed to assure complete blockage of the pulmonary vein (14). The tissue to be ablated may be at any location within the pulmonary vein (14) or in the os of the pulmonary vein (14).

DOCUMENT-IDENTIFIER: US 6238392 B1
TITLE: Bipolar electrosurgical instrument including a plurality of balloon
electrodes

BSPR:
In the above list of possible methods of heating tissue for treatment of
Barrett's Esophagus, the application of RF energy has special interest, and in
particular, the use of a RF balloon surgical instrument to deliver the energy
to a body lumen or cavity. As described in U.S. Pat. No. 2,032,859 by F. C.
Wappler, a RF balloon is especially effective for superficial desiccation or
heating of tissue, such as the inner layer or lining of a lumen or cavity. The
RF balloon described by F. C. Wappler was of monopolar design. Monopolar RF
balloon devices use a first pole ground pad placed upon the exterior of the
patient and a second (mono)pole balloon electrode placed within the patient and
in contact with the diseased tissue. The second pole balloon electrode has an
expandable made from a dielectric or non-conducting material, is filled with a
conductive fluid, and has an electrode adjacent to the balloon and in contact
with the conductive fluid. When applying RF energy to the human body with a
bipolar electrosurgical device, it is important to establish firm contact with
the tissue to reduce the possibility of burns. The balloon electrode, when
inflated within a lumen or cavity within the body, expands outwards to adjust
to the irregular contours of the lumen or cavity and firmly contacts the
diseased tissue. The use of a non-conducting balloon as the tissue contact
surface does not allow the direct coupling of RF energy to the tissue but
rather forms a capacitive coupling with the tissue. The capacitive coupling of
RF energy results in a gentle heating of the tissue in contact

with the balloon
electrode.

BSPR:
Whereas the Wappler bipolar RF balloon was indeed a breakthrough, the invention
required the insertion of a limp or non-rigid balloon into a body lumen or
cavity. Insertion of a non-rigid balloon into a muscular body cavity or lumen
was difficult at best. Geddes et al. in U.S. Pat. No. 4,979,948 addressed
this issue by describing a monopolar RF Balloon having a rigid elongated member
extending longitudinally into the balloon. The elongated member is attached to
the proximal base of the balloon and extends freely into the remainder of the
balloon. This elongated member provides the necessary rigidity to support the
un-inflated balloon during insertion into a body lumen or cavity.
Additionally, the second pole electrode of this invention is placed around the
elongated member extending within the balloon for contact with the electrolytic
or conducting fluid used to expand the balloon.

BSPR:
What was needed was an RF balloon instrument that reduces the possibilities of
uneven tissue heating or balloon burn through. U.S. Pat. No. 4,7676,258 was
issued to Kiyoshi Inokuchi et al. for a flexible monopolar balloon that
attaches both proximally and distally to the distal end of a flexible shaft of
the instrument. Whereas the Inokuchi et al. monopolar balloon utilized
proximal and distal attachment of the balloon to the flexible shaft of the
instrument, the monopolar design required the use of a second electrode that is
placed on the outer circumference of the patient and the use of a constant flow
of cooling fluid. An elongated resilient flexible electrode member (made from
conductive material) that extends into an electrosurgical balloon is described
in the F. C. Wappler U.S. Pat. No. 2,043,083.

BSPR:
All RF balloon inventions described above are monopolar and require the use of a return pole electrode or pad placed in contact with the exterior of the patient. U.S. Pat. No. 5,578,008 was issued to Shinji Hara for a bipolar balloon catheter wherein both the proximal and the distal end of the RF balloon is attached to the catheter (rigid support member) and has both (bipolar) electrodes located within the balloon. The bipolar RF balloon is fixed relative to both the catheter and reduces the possibilities of uneven heating described above. The bipolar electrode design heats the cooling liquid within the balloon and the heated liquid heats the tissue in contact with the balloon.

BSPR:
It would further be advantageous to provide the surgeon with a RF balloon electrosurgical instrument that can fit down the operating channel of an endoscope enabling the surgeon to visually place the balloon electrode at the surgical site. Shinji Hara in U.S. Pat. No. 5,578,008 and Jackson et al. in U.S. Pat. No. 4,676,258 describe the use of pulses or bursts to deliver energy from the electrosurgical generator to the balloon electrode. What is not disclosed in these inventions is the delivery of pulsed or burst RF electrical energy in a preset pattern to produce specific tissue effects.

DEPR:
The present invention is directed to an electrosurgical instrument for heating a lumen or a cavity within a patient. In particular, the present invention is directed to a bipolar electrosurgical instrument for the treatment of Barrett's Esophagus. A bipolar electrosurgical instrument according to one embodiment of the present invention uses a plurality of RF balloon electrodes to heat an inner lining or layer of the esophagus to destroy diseased

tissue, and to stimulate the regrowth of a new healthy inner lining. The embodiment illustrated is minimally invasive and requires the placement of the expandable RF balloon electrodes into contact with the inner lining of the esophagus for the application of RF electrical energy. One embodiment of a bipolar electrosurgical instrument 60 is shown in FIGS. 1-6 and FIGS. 9-11. Methods of using such a bipolar electrosurgical instrument according to the present invention are illustrated generally shown FIGS. 13-17

DEPR:
Flexible return sleeve 92 and flexible elongated tube 71 have hollow passageways for the passage of conductive fluid 74 to the balloon electrodes (FIGS. 5 and 17), and electrical wiring or conductors to conduct RF electrical energy to the balloon electrodes. The electrical wiring and hollow passageways from the elongated members are brought together at the return sleeve body 100. A balloon electrode fluid line 103 and a return balloon fluid line 102 are attached to the return sleeve body 100 for the passage of conductive fluid 74 to the balloon electrode 70a and to the return balloon electrode 90a, respectively, for the expansion of the balloon electrodes. The proximal ends of the balloon electrode fluid line 103 and the return balloon fluid line 102 are connected to a pressurized fluid source 51 for the expansion of the balloon electrodes. Bipolar electrosurgical instrument 60 has a connector cable 67 and an electrical connector 66 (FIG. 1) that are electrically connected to a RF generator 50 (FIG. 13). The RF (Radio Frequency) electrosurgical generator 50 provides RF energy to the electrosurgical instrument, preferably at a frequency between the range of 0.5 MHz to 20 MHz. The connector wire 67 is electrically connected to the balloon electrode 70a by a first pole wire 105 and to the

return balloon electrode 90a by first pole conductor 94.

DEPR:
The distal balloon electrode 70a and the flexible elongated tube 71 are shown in greater detail in FIGS. 4, 5, 6, and 9. Both the balloon electrode 70a and the flexible elongated tube 71 are filled with a conductive fluid 74 (FIG. 5) for the conduction of RF energy to tissue in contact with the balloon electrode 70a. To ensure contact between the balloon electrode 70a and the diseased inner lining of the esophagus, the balloon electrode 70a has an expandable sleeve 75 that is expanded by pressurizing the conductive fluid 74.

DEPR:
FIG. 5 shows a cross section view of the balloon electrode 70a and the elements within flexible elongated tube 71 and FIG. 6 shows an exploded view of these elements. A hollow spacer tube 78 is fixed (not shown) longitudinally within the flexible elongated tube 71. A first pole electrode 72 is fixedly attached about the spacer tube 78 and is located within and proximally recessed from both the distal end of the flexible elongated tube 71 and the expandable sleeve 75. The first pole electrode 72 is formed from wire braid and is electrically connected to the electrical connector 66 and the RF electrosurgical generator 50 (FIG. 13).

DEPR:
The elements of the expandable return balloon electrode 90a are shown in FIGS. 10, 11, and 17. The return balloon electrode 90a has an outer expandable return balloon sleeve 95 that forms a proximal and a distal hermetic seal with the flexible return sleeve 92, and a second pole electrode 91 within. It is important to note that the expandable return balloon sleeve 95 of the expandable return balloon electrode 90a has at least twice the surface area of

the expandable sleeve 75 of the balloon electrode 70a. Second pole electrode
91 is electrically isolated from contact with the patient 33 by the expandable
return balloon sleeve 95 and the flexible return sleeve 92. The expandable
return balloon sleeve 95 can be formed from the same materials as the
expandable sleeve 75 described above and has a lower electrical permeativity
than the flexible elongated tube 71 and the flexible return sleeve 92. A fluid
passage 93 and a first pole conductor 94 run longitudinally within the flexible
return sleeve 92 which is formed from a flexible engineering thermoplastic such
as nylon, polyurethane, polyethylene, or the like (FIG. 17). The fluid passage
93 connects the return balloon electrode 90a with the return sleeve body 100
and the return balloon fluid line 102 for the passage of pressurized conductive
fluid 74 to inflate the return balloon electrode 90a (dashed lines in FIG. 11).
The first pole conductor 94 is electrically connected to the electrical
connector 66 by the second pole electrode 91 and the connector cable 67 for the
passage of RF energy. A distal sleeve 98 and a proximal sleeve 97 are used to
attach and hermetically seal the expandable return balloon sleeve 95 to the
flexible return sleeve 92. Like the balloon sleeve attachment methods
described above, the expandable return balloon sleeve 95 is attached using heat
shrinkable tubing (for the distal retaining sleeve 77 and the proximal
retaining sleeve 76). Other hermetic attachment methods are available such as
glue, heat staking, crimp fittings and the like.

DEPR:
FIG. 13 is a section view of the patient 33, showing the endoscope shaft 42 of
the endoscope 40 insertion into the mouth 26 and esophagus of a patient 33.
The bipolar electrosurgical instrument 60 is attached to the endoscope and the
balloon electrode 70a is extending distally from the operative

channel 43 (FIG.
2) of the endoscope 40. The expandable sleeve 75 of the balloon electrode 70a
is expanded into contact with the inner lining 29 of the esophagus 25 by the
connection of the balloon electrode fluid line 103 to the pressurizable fluid
source 51. The endoscope shaft 42 is curved to place the un-expanded return
balloon electrode 90a into contact with the inner lining 29 of the esophagus 25
to provide the return path for the electrical energy. The return balloon
electrode 90a is larger in diameter than the balloon electrode 70a and need not
be expanded if enough surface area of the expandable return balloon sleeve 95
is in contact with tissue. The electrical connector 66 of the bipolar
electrosurgical instrument 60 is connected to the RF electrosurgical generator
50.

DEPR:
FIG. 14 shows the placement of the balloon electrode 70a at the site of the
columnar epithelium 30 prior to the application of RF energy to the diseased
area of the inner inning 29. The balloon electrode 70a is visible in a viewing
angle 46 of the viewing optics 44 and the surgeon has visually maneuvered the
balloon electrode 70a into contact with the columnar epithelium 30. Ideally,
this maneuvering is done prior to the expansion of the expandable sleeve 75.
The expandable sleeve 75 is shown expanded to contact the diseased columnar
epithelium 30.

DEPR:
FIGS. 15 and 16 shows the placement of the return balloon electrode 90a of the
bipolar electrosurgical instrument 60 just prior to the application of RF
energy. Both the balloon electrode 70a and the return balloon electrode 90a
are expanded and in contact with tissue. In FIG. 16, the balloon electrode 70a
is contacting the columnar epithelium 30 found on the inner

lining of the
esophagus 25 and the return balloon electrode 90a is moving from the initial
position shown in FIG. 15 to the final position shown in FIG. 16. This
movement spaces the return balloon electrode 90a the previously described
distance "L" from the balloon electrode 70a and the effects of this action will
now be described.

DEPR:
FIG. 20 is a cross sectional view along the longitudinal axis of an alternate
embodiment of a bipolar dual balloon end effector 120. Instead of a single
balloon electrode 70a at the distal end of the flexible elongated tube 71, the
dual balloon end effector 120 of the alternate embodiment has a pair of
expandable electrodes side by side in a longitudinal orientation. FIG. 20 is a
cross sectional view taken perpendicular to the longitudinal axis of the dual
balloon end effector 120 and shows a cross section of a first pole balloon
electrode 125 on the left and a cross section of a second pole balloon
electrode 130 on the right. First pole balloon electrode 125 and second pole
balloon electrode 130 are separated by an isolator wall 121 to prevent contact
between the balloon electrodes and are backed by a proximal end plate 122.
Each balloon electrode 125, 130 is identical to and a mirror image of the
other. The first pole balloon electrode 125 has a first pole balloon sleeve
126 that is expandable by the addition of conductive fluid 74 from the
pressurizable fluid source 51. The conductive fluid 74 is conducted into the
first pole balloon sleeve 126 by a first pole fluid passage 127 that extends
through the flexible elongated tube 71 that is connected to the pressurizable
fluid source 51. A first dual electrode 128 is recessed into the proximal end
plate 122 for the delivery of electrical energy to the first pole balloon

electrode. Like the mirror image first pole electrode 125 described above, the second pole electrode 130 has a second pole balloon sleeve 131, a second pole fluid passage 132, and a second dual electrode 133. The application of RF energy to bipolar dual balloon end effector 120 heats the adjacent tissue by capacitive coupling much in the manner described above. Heating effects from this design are more pronounced along a horizontal plane that runs through the first dual electrode 128 and second pole balloon fluid passage 132. Less heating is found along a vertical plane established by the isolator wall 121. This type of end effector provides the surgeon with localized and opposite lobes of heating which can leave healthy tissue between the lobes unscathed.

DEPR:
FIG. 25 shows yet another alternative embodiment of an alternate bipolar electrosurgical instrument 140 wherein the alternate embodiment has a multiplicity of expandable electrodes spaced longitudinally along the longitudinal axis of the alternate bipolar electrosurgical instrument 140. In FIG. 21, three balloon electrodes are shown, distal balloon electrode 70a, return balloon electrode 90a, and an alternate balloon electrode 141 located proximally from return balloon electrode 90a. A switching network 142 is provided to switch the application of bipolar RF energy from the distal balloon electrode 70a and the return balloon electrode 90a to the alternate balloon electrode 141 and the return balloon electrode 90a. This switching effectively enables the surgeon to move the application of RF energy from the distal most balloon electrode 70a to the proximal most alternate balloon electrode 141 without moving the bipolar electrosurgical instrument 120. It is important to note that the central return balloon electrode 90a is at least twice the size

of the proximal alternate balloon electrode 141 and the distal balloon electrode 70a. Also of note is the distance "L" between the pair of selected balloon electrodes is at least twice the longitudinal length of the return balloon electrode 90a or alternate balloon electrode 141. This ensures that the smaller of the two balloon electrodes selected has the highest current density surrounding it to confine tissue-heating effects to tissue directly adjacent to the smaller balloon electrode.

DEPR:
In yet another embodiment of the invention and as shown in FIGS. 22-24 the output of the RF electrosurgical generator 50 to the bipolar balloon electrodes is altered from a continuous sinusoidal output 150 (FIG. 22) to a pulsed "burst" mode 155 (FIG. 24). The output of a RF generator 51 in cautery mode is a continuous sinusoidal output 150 of a frequency dependent on the generator and at a typical current of 0.75 to 1 amps (FIG. 23). In "burst" mode 155, the sinusoidal output 150 of the generator is retained but the application of the waveform to tissue is broken up into discreet "bursts" or pulses of energy separated by periods of no energy application. The bursts of energy 156 are applied for approximately 2-100 milliseconds, and most preferably around 10 milliseconds. The bursts of energy 156 are applied at a rate of 2 to 500 Hz and most preferably between 50-100 Hz. The current 151 applied during the pulse is increased to between 1.5 to 5 amps and most preferably at 2 amps. Providing bursts of increased current 151 results in the average power being kept between 2-100 watts and most preferably below 20 watts. By providing short bursts of energy 156 of higher current 151, the net energy applied to the tissue is less or equal to the energy applied by the steady sinusoidal output 150 of an unmodified RF generator.

DEPR:
Testing has shown that the application of pulsed RF energy in the manner
described above results in decreased internal heating of the conductive fluid
within the balloon electrode, and limits the depth of penetration of the RF
energy into the wall of the lumen. Additionally, tissue effects produced by
the bursts of energy 156 are visually different from tissue treated with a
continuous output sinusoidal waveform 150, and have more of a "sunburned
tissue" effect than the more typical "cooked tissue" effect produced by the
application of continuous sinusoidal RF energy.